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ABSTRACT

This booklet is designed to make available research findings about football with interpretations for practical application. Chapter 1, "Physical Characteristics of Football Athletes," includes a table comparing the height and weight of National Football League players and All-Star players. Somatotyping and body composition are discussed. In chapter 2, "Psychological and Social Characteristics of Football Athletes," the following aspects are considered: a) emotionality, b) personality factors, c) arousal and performance, d) success and the level of aspiration, e) career aspiration, and f) academic achievement and football participation. In chapter 3, "Speed of Movement in Football," the following topics are discussed: a) starting speed and body position, b) starting signals and movement, c) sprint running, and d) starting speed and blocking performance. Chapter 4, "Physiological Aspects of Football," includes a discussion on heat illness, nutrition and diet, body fat, metabolic level, and preseason medical evaluation. Chapter 5, "Football Injuries," presents statistics on football fatalities and considers injuries to the upper and lower extremities, heat illness, and injuries on synthetic turf. A bibliography concludes each chapter. (PD)

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WHAT RESEARCH TELLS THE COACH ABOUT

FOOTBALL

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FOOTBALL

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WHAT RESEARCH TELLS THE COACH SERIES

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What Research Tells the Coach About Wrestling
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FOREWORD

This is the fifth in a series of booklets titled "What Research Tells the Coach" about a particular sport or activity. The purpose of these booklets is to make available to coaches pertinent research findings with interpretations for practical application.

The author of this booklet, Roderick R. Paige, is a graduate of Jackson State College and Indiana University, where he earned his doctorate degree. He is presently head football coach at Texas Southern University, Houston. Prior to this assignment, he was head football coach at Jackson State College, Jackson, Mississippi and then assistant football coach, University of Cincinnati. We are pleased that a football coach of such preeminence accepted the assignment.

We believe this booklet is the first of its kind to be published. The material is both practical and scholarly. It is believed that the information will help reinforce some beliefs now held and in other instances open avenues to the acceptance of new ideas. We hope that football coaches, whatever educational level they represent, will find this book valuable.

John M. Cooper

PREFACE

Coaching football is a very complex task. Football is a game that requires physical strength and great physiological conditioning. Thus, a successful coach must know a great deal about factors contributing to the development of physical strength and understand how the body reacts to physiological conditioning. Football is a team sport. Therefore, the coach needs to know how to manipulate the psychological factors which influence individuals to interact for a common goal. Since football is a game of movement, the coach must understand the physical mechanics which contribute to quick body movement. Because football is a game of violent body contact, a coach needs to know how to create practice and playing conditions that offer the greatest safety to the players. Inasmuch as football involves many physical skills, it is necessary for the coach to understand the mechanics of these skills.

Because a successful football coach needs to know so many varied skills and concepts, it is not surprising that many people feel that coaching football is more an art than a science. There is some evidence to support this contention, and history has shown that the truly great football coaches have combined skill and knowledge of many situations and have been aware of the value of using the best methods and techniques in each coaching situation. Determining which of the many coaching methods is best for a specific coaching situation is the football coach's challenge.

Much research dealing with football techniques has been reported in scholarly literature. Unfortunately, a great deal of it has been available only in unpublished masters' theses, doctoral dissertations, professional journals and other periodicals which are not readily available to coaches. This monograph represents an attempt to survey the pertinent research literature, evaluate it and present that part of it which is likely to be useful to football coaches and trainers. It is hoped that the material will help the coach who wants to know what research tells about the many questions regarding football.

The writer wishes to express sincere gratitude to an unselfish group of individuals who were of invaluable help in the preparation of this monograph. Among these are George Cousins, Professor of Physical Education, Indiana University, who taught me to search for truth; John M. Cooper, Professor of Physical Education, Indiana University, who had kept the faith despite my procrastination; Bonnie Bruce, who typed and edited the manuscript; Dave Kenoson, Head Football Coach, North College Hill High School, Cincinnati, Ohio, who wrote the chapter on "Physiological and Social Characteristics"; my wife, Gloria and son, Rod, Jr., who were my inspiration; and the many researchers whose work served as the bases for this publication.

Rod Paige

1. PHYSICAL CHARACTERISTICS OF FOOTBALL ATHLETES

A leading sports publication (16) recently credited Dr. Howard C. Knuttgen of Boston University with the comment, "Physical size and body proportion are of extreme importance to performance — in general, a good big man is of more value on performance than a good small man." An NFL survey (21) that compared by position the height and weight of the average NFL player with the height and weight of the NFL all-star performer at that position tends to support Dr. Knuttgen's claim (see Table 1).

It can be seen from Table 1 that while the backs and receivers who made the all-star team weighed about the same as the average NFL player, in the other positions there seems to be a direct relationship between height, weight and success.

The 1971 Super Bowl Champion Dallas Cowboys were taller and heavier than the 1971 average NFL players in height and weight:

Team	*Average Height*	*Average Weight*
Average Dallas Cowboy	6' 2.7"	224.0
Average NFL Player	6' 2.1"	222.5

Bend (2) grouped approximately 14,000 male students into four groups according to levels of athletic participation (Table A). Group I represented the lowest of athletic participation (the nonathlete) and Group IV represented the highest level of athletic participation (the superior athlete). In terms of height and weight, his findings reinforce Knuttgen's conclusion.

TABLE I. NFL PLAYERS
ALL-STAR vs AVERAGE

	HEIGHT	WEIGHT
ALL-STAR QUARTERBACK		
Bart Starr	6-1	200.0
Average All-Star	6-1	200.0
Average Player	6-2	200.4
ALL-STAR TIGHT END		
John Mackey	6-2	217.0
Average All-Star	6-2	217.0
Average Player	6-3	224.9
ALL-STAR RUNNING BACK		
Leroy Kelly	6-0	195.0
Gale Sayers	6-0	198.0
Average All-Star	6-0	196.5
Average Player	6-1	217.0
ALL-STAR WIDE RECEIVER		
Bob Hayes	5-11	189.0
Dave Parks	6-2	207.0
Pat Studstill	6-0	175.0
Average All-Star	6-0	190.0
Average Player	6-1	195.0
ALL-STAR INTERIOR LINEMEN		
Bob Brown	6-4	290.0
Forrest Gregg	6-4	250.0
Jerry Kramer	6-3	245.0
John Gordy	6-4	250.0
John Thomas	6-4	250.0
Gene Hickerson	6-1	248.0
Mick Tingelhoff	6-1	237.0
Average All-Star	6-3	252.9
Average Player	6-3	247.5
ALL-STAR RUSH LINE		
Willie Davis	6-3	245.0
Deacon Jones	6-4	261.0
Bob Lilly	6-5	255.0
Merlin Olsen	6-5	276.0
Average All-Star	6-4	259.0
Average Player	6-4	253.6

TABLE 1. NFL PLAYERS ALL-STAR vs AVERAGE (Continued)

	HEIGHT	WEIGHT
ALL-STAR LINEBACKER		
Ray Nitschke	6-3	240.0
Chuck Howley	6-2	223.0
Lee Roy Caffey	6-3	250.0
Maxie Baughan	6-1	227.0
Average All-Star	6-2	235.0
Average Player	6-2	230.1
ALL-STAR DEFENSIVE BACK		
Herb Adderley	6-0	210.0
Bob Boyd	5-10	215.0
Cornell Green	6-3	215.0
Larry Wilson	6-0	190.0
Willie Wood	5-10	190.0
Average All-Star	6-0	204.0
Average Player	6-1	192.1

TABLE 2. HEIGHT AND WEIGHT

Height/Weight	Group I (Median)	Group II (Median)	Group III (Median)	Group IV (Median)
Height	5' 10.5"	5' 10.8"	5' 10.9"	5' 11.2"
Weight	150.9 lb.	153.2 lb.	156.9 lb.	160.9 lb.
Number	2,813	3,526	4,433	3,031

Studying the somatotypes of the 1964 San Diego football team, Carter (3) found that the successful college football athletes were outstanding for their height and weight, their high endomorphy and mesomorphy and low ectomorphy when compared with the general population. When comparisons were made between linemen and backs, the backs were found to be significantly lower on endomorphy (−0.79) and higher on ectomorphy (0.63) than the linemen, and they were significantly shorter (−1.82 inches) and lighter (−33.06 pounds) than the linemen. Successful football athletes were found to be largely endomorphic-mesomorphic types.

There are conflicting reports on the relationship between flexibility measurements and somatotype components. Using 14 measures of flexibility, Laubach and McConville (12) found a lack of relationship between somatotype components and flexibility. Tyrance (20) found that neck thickness (front to back)

is the most significant somatotype variable in the prediction of flexibility and that as neck size increases, the range of hip flexion decreases significantly while general flexibility decreases gradually. Although flexibility cannot be predicted from anthropometric measurements (12, 13), it decreases as body fat increases. While strength is related to mesomorphy, there seems to be little relationship between muscle strength and flexibility.

Laubach and McConville (13) reported a low but statistically significant correlation between hip flexion strength and the range of motion of hip extension flexion. Interestingly, football players are more flexible than nonfootball players only in the area of trunk-hip flexion (19). In other joint areas, nonfootball players are more flexible than football players.

The relationship between body build and success in football has interested coaches and researchers in physical education for many years. In an early study DiGiovanna (8) reported that of the many variables involved in athletic success not (of) the least important appeared to be body structure, muscular strength and explosive power. DiGiovanna found that the individual who is likely to succeed as a back in college football is moderately heavier and stronger and much more powerful than the average student. The individual who is likely to succeed at line positions in college football is much heavier and stronger and moderately taller and more powerful than the average student.

Somatotyping

There is considerable evidence that an individual's body type predisposes him to advantages or disadvantages in certain sports or certain positions within specific sports. The classification of body types is known as somatotyping. Sheldon's (18) method of classifying the male physique into three major types — endomorphic, mesomorphic and ectomorphic — is currently one of the most widely used methods of classifying body types.

Flexibility can be improved significantly through stretching exercises. The static and ballistic methods of stretching are equally effective in improving flexibility (6), but the static method seems preferable because it obviates the bouncing, bobbing or jerking movements involved in the ballistic method, thereby reducing the chances of injury as well as the energy required for the exercise.

Muscular strength is related not only to body size (especially to weight), but also to the mesomorphic component of body build (9). There seems to be little relationship between mesomorphy and weight. An athlete need not be of great weight in order to be high in mesomorphy. Weight alone accounts for only 25 percent of the strength variance; however, if body build and height are considered, 75 percent of the strength variance is controlled (9). This points out that whereas strength is fairly independent of body weight, when body size and build are considered together, they provide a good representation of the factors determining strength.

Body Composition

Most coaches agree that body fat is a liability to performance of motor skills and physical activity. The heavier the weight of an athlete in relation to his body build, the greater the limitation of his physical skills and efficiency in motor activities (15). Whereas body weight per se is not damaging to skill in motor activities, the proportion of fat tissue in the body's composition is of paramount importance to skill development. As body fat increases, flexibility decreases (12). Endomorphy is the only somatotype component related to flexibility, and that relationship is a negative one. Riendeau and his colleagues (17) found negative correlations (−0.29 to −0.68) between the percent of body fat and scores made on selected motor fitness tests. Activities that involve running and jumping are affected most by body fat. Weight in itself does not significantly affect running performance except in runs like the 220-yard dash and farther. Kireilis and Cureton (11) report a negative correlation (−.578 to −.264) between performances of strenuous physical exercises and the amount of external fat on the body. These findings reinforce the conclusion that body fat is a handicap in most strenuous exercises. The location of the fat is also important. For example, in strenuous endurance running, fat on the abdomen and buttocks appears to be more of a disadvantage (−.737 to −.588) than fat on the thighs and cheeks (−.394 to −.226) (11).

When an athlete participates in a strenuous training program, weight is not a good guide to fat loss. It is not uncommon to find that under training conditions, body weight increases despite a decrease in body fat (14). In determining the optimum weight for athletes, standard height-weight-age tables have proven to be inadequate (22). Since weight in relation to unit volume of tissue, rather than absolute weight, is the more useful index, what is needed is a method to estimate body composition rather than a table of averages. Several methods of estimating body fat are presented below.

Hydrostatic weighing has been used successfully to determine the percent of body fat. This method consists of finding the specific gravity of the subject and using it in a formula such as the one devised below by Rathburn and Race (10). Specific gravity may be determined by weighing the person in the air and in water (Archimedes' Principle), and then determining the ratio of air weight to underwater weight.

$$\text{Specific Gravity} = \frac{\text{Weight in Air}}{\text{Weight in Air} - \text{Weight in Water}}$$

The Rathburn–Race formula is:

$$\text{Percent of Fat} = 100 \left(\frac{5.548}{\text{Specific Gravity}} - 5.044 \right)$$

Percent of body fat determined by this method was found to correlate .972 with percent of fat determined by chemical analysis of cadavers (14).

A much simpler method of estimating body fat is the skinfold method, which measures the thickness of a "pinch" of tissue from various sites on the subject's body. This pinch of tissue, the skinfold, includes a double layer of skin plus subcutaneous fat. The amount of body fat under the skin reflects itself in the thickness of the skinfold. The skinfold caliper is an instrument that measures skinfold. Skinfold thickness decreases or increases as weight is lost or gained respectively (10). The percent of body fat determined by the skinfold method correlates very highly with the percent of body fat determined by the more laborious hydrostatic method (23). Since skinfold measurements taken at various sites on the same subject are highly correlated (10), a good estimate of the percent of body fat can be determined from as few as three or four skinfold sites.

Damon and Goldman (5) report that the percent of body fat determined from two standard skinfold sites, triceps and subscapular, is almost as accurate as the percent of fat determined from densitometry. For an explanation of the skin method of measuring body fatness, the coach should read Montoye (14).

Fat tissue has useful functions, and the well-conditioned athlete should maintain sufficient fat reserves for proper health. However, the body is considered obese if 20 percent or more of body weight is composed of fat tissue (7). The body fat percentage for a football athlete in good shape might range between 7 to 14 percent of his body weight (7, 4), depending upon the position he plays on the team. To be effective, backs and ends should generally have a smaller percentage of body fat than linemen.

Summary

Physical structure and body proportion are important factors in determining success in football. Football players are heavier and stronger than their peers and are generally endomorphic and mesomorphic types. They tend to be less flexible than nonfootball players except in hip flexion extension. To improve their flexibility, the static method of stretching is recommended.

With the possible exception of neck thickness, there is little if any relationship between somatotype components and flexibility. Also, there is little if any relationship between flexibility and strength. However, muscular strength is related to body size and mesomorphy. Body size, when considered with body build, provides a good estimate for general body strength.

Excessive body fat is a hinderance to motor skill development and efficiency in physical activities. In assessing athletes' amount of body weight, height-weight tables are inadequate. The preferred method of determining the percent of body fat is through skinfold measurements. The normal body fat percentage for young men ranges between 7 and 14 percent of their body weight.

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2. PSYCHOLOGICAL AND SOCIAL CHARACTERISTICS OF FOOTBALL ATHLETES

While the relationship between body structure and success in football activities has been reasonably well established, the less tangible relationship between psychological variables and athletic success has been exceedingly difficult to determine. The search for functional relationships between football success and numerous psychological and sociological variables has generally met with frustration. Although most football coaches believe that personality and sociability factors have substantial influence on athletic performance, this belief has not yet been proven. The dilemma ranges from problems of defining many of the psychological and sociological factors to interpreting findings from studies that used questionably valid instruments. But despite its shortcomings, psychological research in athletics has much to tell the coach about football.

Generally, the goals of sports research in psychology and sociology have been to identify and evaluate personality types, evaluate the personality makeup of champion athletes and understand the association between physical, social and personality variables.

Emotionality

Most research in this area suggests that emotional stability is germane to athletic success. Ogilvie (15) characterizes emotional stability as facing reality calmly, learning to control feelings, refusing to retreat to immature solutions for conflicts, and avoiding emotional upset and feelings that might interfere with problem solving.

One of the earliest attempts to explore the relationship between emotions and competitive physical activities was made by Johnson (10). Using subjective

and objective measures, he measured the emotions displayed by 15 football players and 5 wrestlers toward impending athletic competition. The subjective measurement consisted of observing and questioning the athletes. The objective test consisted of obtaining the heart rate, blood pressure and blood sugar of each athlete. The measurements were taken a few days before, a few hours before, just prior to, and immediately after, competition. Johnson found that the football players were less affected emotionally by impending competition than were the wrestlers. Although as a group, the football subjects experienced very little pregame emotions, the period of most emotional stress occurred just prior to competition.

Ibrahim (8) used the Guilford-Martin Inventory to compare temperamental traits among 96 male and 40 female college athletes and physical education majors. The male subjects were basketball, football and baseball players and physical education majors. The female subjects were dancers and physical education majors. Ibrahim found that the football group scored above average in the following factors:

> *General Activity* (65th Centile) — A tendency toward vigorous and quick muscular activity in contrast to disinclination to such activity.
>
> *Ascendency-Submission* (60th Centile) — Social leadership or tendency to come to the forefront in a social situation in contrast to taking a more passive or inconspicuous role.
>
> *Masculinity-Femininity* (60th Centile) — Typically masculine in emotional and temperamental makeup (emotional toughness) in contrast to feminine makeup.
>
> *Inferiority Feeling* (60th Centile) — Feeling of inadequacy and self-depreciation in contrast to self-confidence.

Certain evidence suggests that the different positions in football have different emotional requirements. Tutko and Ogilvie (9) maintain that defensive linemen are more emotionally mature, toughminded and team-oriented than most other players and that defensive backs exhibit a high degree of emotional stability and mental toughness.

Walker (25) suggests that a player's social and emotional adjustment may be affected by experiencing a losing season. He administered the Washburne Social Adjustment Inventory (WSAI) to members of the football teams of the Missouri Intercollegiate Athletic Association Conference prior to the opening of the 1965 season. At the end of the season he readministered the test to the two top and two bottom teams. The two losing teams scored lower on the traits of total adjustment, sympathy and control at the end of the season than at the start of the season while the winning teams showed no changes in the preseason—postseason scores.

In Anspaugh's study (1) of the leadership characteristics of basketball players, he found the following:

> Generally, winning and losing team members disagreed with their coaches' choices on the player who exhibited the least social-emotional leadership. It was also noted that the greater a team's winning percentage, the greater was the agreement between the team members and the coach on the responses to the sociometric questionnaire.
>
> A great deal of difference was noted between the season objectives of winning and losing teams. The objectives given by winning teams were more concrete and definite. The losing teams had objectives which were considered to be more personal in nature . . . and often more indefinite and transitory.

Anspaugh also noted that the leadership quality was clearly more evident on winning teams than on losing teams.

The preponderance of evidence in this area suggests that other than during the period just prior to games, football players show very little pregame emotions. In terms of temperamental traits, football players generally are inclined toward more activity, social leadership and emotional toughness than other athletes and nonathletes. In spite of their tendency to stand out in front in social situations, they are inclined toward feelings of inadequacy and self-depreciation. Although winning football seasons appears not to improve players' social and emotional adjustments, losing seasons may contribute to players becoming less well adjusted in terms of total adjustment, sympathy and control.

Personality Factors

Personality factors have substantial influence in determining who becomes attracted to and who excels in football. Kane (11) points out that the "football type" is identifiable by his high degree of self-control and extrovertal traits reflecting urgency and rough-mindedness. Rhode (17) observed that the young football players who make the team in the youth league are probably more intelligent and tough-minded than those who fail to make the team.

The findings of Berger and Littlefield (3) stand in opposition to the "football type" personality. In 1969 they conducted a study to determine whether personality differences existed among 30 outstanding football athletes, 30 nonoutstanding football athletes and 30 nonathletes. After controlling for scholastic aptitude, the subjects were administered the California Psychological Inventory (CPI). The analysis of variance found no significant difference at the .01 level among the subjects on any of the 18 items of the CPI nor on the composite score.

The common belief that athletes of different sports and from various types of schools (e.g., private university, state college) have similar behavior characteristics that set them apart from other groups of athletes was studied by Lakie

(14). He administered five scales from the Omnibu Personality Inventory to 230 athletes from a state university, a private university and two state colleges. The five scales used in the study were: Complexity of Outlook, Social Maturity, Social Introversion, Liberalism and Aggressive Activity. The subjects were divided into basketball, football, tennis, golf, track and wrestling groups. Lakie found that the inventory did not distinguish between the different sports groups as a whole. For the sports groups within individual schools, football players had a lower mean score on the Social Introversion scale than track men, and private university football players were found to be less introverted than those from state colleges.

In 1964 Kroll and Petersen (13) used the Cattell 16 PF Test to compare personality trait differences between winning and losing football teams. Six teams (N=176) were studied. Using three separate discriminate analyses, they found the social factor to be the one common difference between the winning and losing teams. This finding, which is the reverse of what one would expect, suggests that winning teams have less of a sportsmanlike attitude than losing teams. Since a high score on the social variable is associated with personality traits such as love, kindness, sympathy and unselfishness, their findings suggest that these traits are inconsistent with winning football. Interestingly enough, players from universities, state colleges and private schools scored from low to high respectively on the social variable.

Slusher (22) compared football players judged highly sportsmanlike with players judged unsportsmanlike. He reported that although the sportsmanlike group came closer to approaching the ideals of society, both groups were so far from these ideals that neither group could be considered to possess great sportsmanlike values.

The most significant personality traits associated with physical excellence, according to Ogilvie (15), are: emotional stability, toughmindedness, extroversion, conscientiousness, self-discipline, freedom from jealousy, trustfulness, self-assurance, and relaxed low-tension level. Football coaches would be well advised to give high regard to these traits in teaching winning football. Other important personality traits according to Tutko and Richards (24) are drive, determination, intelligence, aggression, leadership and organization.

A study of personality and intelligence characteristics of 100 nonathletes and 400 baseball, basketball, swimming, wrestling and football athletes led Slusher (21) to believe that football athletes are likely to use physical means under stress as a way of solving difficult conflicts. Using selected profile scales from the Minnesota Multiphasic Personality Inventory (MMPI) and intelligence quotients, Slusher found that football players displayed a high degree of hypochondriasis, hysteria, hypomania and psychopathic deviations. They also showed a higher level of intelligence than any of the other athletic groups, but scored significantly lower than the nonathletic group. He concluded that

the football and wrestling groups demonstrated the most neurotic profiles of all groups measured. In drawing conclusions from this study, one should consider that the MMPI is designed to assess the nature of emotional upset — such as neurotic and psychotic tendencies — in adults.

Tillman (23) reports that personality is influenced by physical fitness. He conducted a study in which personality traits of boys who ranked in the upper 15 percent on a physical fitness test were compared with the personality traits of boys who scored in the lower 15 percent in physical fitness. He found that the upper 15 percent exhibited more dominance and extroversion and were more socially oriented. Tillman's findings reinforce those of Cowell and Ismail (4). After studying the relationships between selected social and physical measures, they found that the subjects who scored highest on physical fitness were more likely to have leadership potentialities, to be accepted at close personal distance by associates and to be well adjusted socially.

The popular belief that participation in competitive sports contributes to character and personality development is not supported by research studies. One of the best controlled studies in this area was done by Rushall (18). Using the 16 PF Test to study the 1966, 1967 and 1968 Indiana University football teams, he concluded that personality changes are not attributed to participation in college football. Rushall's conclusions reinforce the findings of Werner and Gottheil (26). They studied 340 cadet athletes and 116 cadet nonparticipants entering the United States Military Academy. Each subject was administered the 16 PF Test shortly after entrance and again shortly before graduation. Despite four years of regular athletic participation, the nonparticipants did not change in personality structure to a greater extent or in a different pattern than the athletes, nor did they become more like the athletes. Ogilvie's findings (15) also support the theory that participation in college athletics does not influence personality significantly.

Despite some evidence to the contrary, most evidence indicates that football athletes are outstanding for their roughmindedness, extroverted tendencies and self-control. There is some indication that despite the footballer's extrovertal traits, he is not as sure of himself as his actions indicate. An athlete's psychological and sociological traits may be more linked to the type of school he attends than to a specific sport in which he participates. This is especially true of the social variable. The disturbing finding that winners are less sportsmanlike than losers probably reflects the "win at all cost" attitude sometimes found in winning teams. Giving attention to social factors is especially pertinent in view of Slusher's suggestion that even the most sportsmanlike football athletes fall short of great sportsmanlike values.

Contrary to popular opinion, there is strong doubt that sports participation per se contributes to positive personality and character development. There is, however, reason to believe that losing seasons can damage a player's social and emotional adjustment.

Arousal and Performance

Many football coaches believe that performance is a function of arousal. Actually, under some conditions the reverse is true. Evidence seems to indicate that different tasks require different amounts and types of arousal for best performance. In fact, optimum arousal levels not only vary with the particular motor task, but also from person to person, and sometimes from time to time within the same person. According to the Yerkes-Dodson Law, which has served as the guideline for optimum arousal for motor tasks, complex tasks are performed better when one's drive is low, while simple tasks are performed better when drive is high. Oxendine (16), however, points out that the Yerkes-Dodson Law is inadequate for today's needs and offers the following guidelines:

1. A high level of arousal is essential for optimal performance in gross motor activities involving strength, endurance and speed.
2. A high level of arousal interferes with performance involving complex skills, fine muscle movement, coordination, steadiness and general concentration.
3. A slightly above-average level of arousal is preferable to a normal or subnormal state for all motor tasks.

Physical strength is enhanced by high levels of arousal. Many extraordinary feats of strength have resulted from a very high arousal state. On the other hand, because high arousal states are detrimental to the performance of complex and fine controlled movements, coaches should keep in mind that during the learning stage of motor tasks players' state of arousal should be kept low for best results. Hussman (7) points out that as arousal increases, functioning intelligence decreases.

In general, optimum amount of pretask tension is useful for excellent performance. The optimum arousal level is a function of the motor task, the person performing the task and the amount of familiarity the performer has with the task. The greater a person's familiarity with a task, the greater his tolerance for arousal.

Success and the Level of Aspiration

An athlete's goals determine his level of aspiration. Once these goals are set, the athlete uses them as standards to judge the degree of success or failure of his performances. Smith (19) studied the influence of athletic success and failure on the level of aspiration of the 1947 football squad of the University of California. He interviewed the subjects privately on Wednesday, Thursday and Friday preceding Saturday games. In these interviews Smith determined the amount of playing time each subject expected to play in the Saturday game (immediate level of aspiration) and the maximum number of minutes he expected

to play in some future game (ultimate level of aspiration). A record of the number of minutes played by each subject was kept. Smith found that the players who quit the squad before the end of the season could be predicted quite accurately on the basis of their immediate aspiration level. Those athletes who had little hope of playing were likely to consider quitting. Smith concluded the following:

1. There is a tendency for successful individuals (those who get to play the most) to raise their level of aspiration, and for failure (those who get to play the least) to lower their level of aspiration.
2. Individuals who have extremely low levels of aspiration, after having experienced failure objectively, tend to escape by overt action which removes them from the failure-producing situation.
3. Individuals with somewhat higher levels of aspiration maintain some hopes of success and repeatedly experience failure.
4. Individuals with the highest levels of aspiration tend to repeatedly exceed their level of aspiration and experience success, even though this success has caused them to raise their aspiration level.
5. The ultimate level of aspiration is uncorrelated with ultimate accomplishment.
6. The immediate level of aspiration is definitely correlated with immediate accomplishment and related to toleration of, or escape from, the failure-producing situation.
7. These facts suggest that in real-life athletic situations, such as those occurring in the case of the freshman football squad, a considerable number of the players are forced to experience failure repeatedly and consistently.

Considering Smith's findings, the alert football coach would be well advised to find a method of offering encouragement to players who experience little playing time. The evidence suggests that a player's level of performance is not likely to exceed his level of expectation.

Career Aspiration

Project Talent is a 20-year longitudinal study of 400,000 American high school students who were originally tested in 1960 and whose careers will be followed until 1980. Using data from the project's first five-year (1965) follow-up, Bend (2) discovered some interesting facts regarding the academic and career aspirations of athletes. On the basis of past athletic participation, the subjects were divided into the following groups.

Athletic Group I – Nonathlete
Athletic Group II – Casual athlete

Athletic Group III – Specialized and activity athlete
Athletic Group IV – Superior athlete

Analysis of the data revealed that the superior athletes aspired to college attendance and actually started college in greater proportions than the nonathletes. The nonathletes were undecided about careers in greater proportion than the superior athletes. As can be seen in Table 1, students in higher athletic participation groups expected to obtain a greater amount of education than their peers.

TABLE 1. GREATEST AMOUNT OF EDUCATION EXPECTED (1960)

Educational Expectations	Group I (Percent)	Group II (Percent)	Group III (Percent)	Group IV (Percent)
Not graduate high school	4.9	0.7	0.8	0.6
High school graduate only	23.4	17.6	14.0	9.8
Junior college, technical, vocational	15.6	14.1	11.5	7.8
Some four-year college	7.9	8.3	7.7	8.3
Four-year college graduate	24.1	31.8	37.2	43.4
Advanced degree	24.1	27.5	28.7	30.1
Percent	100.0	100.0	99.9	100.0
Number	4,766	3,481	4,392	3,011

Beod found that the careers which superior athletes valued most were business and education, while the careers they valued least involved manual labor and "hard science".

Football can be a valuable activity for aiding young people to aspire to meaningful careers.

Academic Achievement and Football Participation

The effect of football participation on academic achievement has been examined recently by several sports researchers. Smith (20) compared the Kent State University varsity and freshman football players with an individually matched sample of nonathletes in terms of academic achievement. He found that although the nonathletes were the better achievers during the quarters that included the football season, over the long haul there was no significant difference in the academic achievement of the two groups.

After studying varsity athletes of all sports at Central Michigan University, Kirchner (12) also concluded that athletic participation did not have a detrimental effect upon academic achievement.

After studying the Project Talent data, Bend's overall impression was that superior athletes do better than nonathletes in earning high school grades but that this difference does not continue into college. He found that in college the superior athletes tend to be slightly less represented at both the higher and lower ends of the grade continuum.

After comparing the academic performance of football players with that of student leaders, Harwick (5) found that the student leaders were the better performers on both grade point average and on the American Council of Education Psychological examination and that they had a lower failure rate. According to Hillyer (6), a greater percentage of football players suffer academic probation than do nonfootball players. From a five-year study of Southeastern Conference football players, he found that football players' entrance exam scores were lower than nonplayers. In spite of the above findings, Hillyer observed that there was no significant difference between footballers and nonfootballers in regard to grade point average, percentage graduating and percentage classified as failures.

Evidence regarding football participation and academics indicates that football players are much like other students academically. However, the coach must be especially watchful of his players' academic studies during the football season.

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3. SPEED OF MOVEMENT IN FOOTBALL

A player's ability to mobilize his body quickly and cover specified distances in the shortest possible time is undoubtedly one of the most vital skills to success in football (13). To be successful, a player must be able to make sudden and rapid adjustments to the constantly changing stimuli of the game. During the course of a game a player will encounter situations requiring quick movement in a forward, backward or sideward direction. The speed at which he can execute these movements is often the factor that determines whether or not his objectives are accomplished. A player's ability to react and move quickly is influenced by many factors, some of which are initial body position, signal presentation, holding time and initial step pattern.

Starting Speed and Body Position

Extensive research has been done on speed and quickness in football. As early as 1934, Dickinson (6) recognized the importance of foot spacing to quick starting time in track. Using 26 experienced sprinters as subjects, he investigated the effect of foot spacing upon the time required for the sprinters to leave their marks and the time required to cover a distance of 7½ feet. The four types for foot spacing studied were:

1. Elongated Start — A position in which the knee of the back leg is opposite the heel of the front foot in a kneeling position.
2. Medium Start — A position in which the knee of the back leg is opposite the front of the arch of the front foot in a kneeling position.
3. Bunch or Bullet Start — A position in which the toe of the back foot is opposite the back of the heel in a "standing" position.
4. Natural Start — A position which the sprinter felt to be most natural to him.

Starting time was defined as the time elapsed between a gunshot and the breaking of contact by the front foot. The hip-shoulder elevation was not controlled, but the hip height was described as being level with, or higher than, shoulder height. Each sprinter performed 32 starts on three occasions. Dickinson reported that for the starting time, the bunch start was significantly the fastest and the elongated start was the slowest. On the other hand, for the 7½ foot distance, the bunch start resulted in the slowest time while the elongated start resulted in the fastest time. The findings of Owens' study (17) support those of Dickinson.

After studying the effect of hip elevation on the starting time of sprinters, White (22) found that the high hip position from the bunch start yielded the fastest starting time. He found that as the angle at the hip decreased, starting time got slower, and as the hip angle increased, starting time got faster. Fitch (12) offered support for White's conclusion. In his investigation, which was designed to determine which football lineman's stance is best suited for starting speed, Fitch studied the following varieties of starting directions — straight ahead, 90 degrees left, 90 degrees right, 45 degrees left and the pass block. He also studied two variations in body position — weight back position and weight forward position, and three variations in stance — four-point parallel, three-point parallel and three-point foot back. He found that the weight forward position was fastest for (a) starting ahead and (b) at 45 degrees right and was as fast as the weight back position when starting in directions other than to the right. The body position finding held true regardless of the type of stance used.

Deck (4) reported a study of the effect of stance, body position and initial step patterns upon primary backfield speed. He found that primary backfield speed was not affected by any of the variations of stance or initial step pattern used in his study. On the basis of the results obtained from a comparison of the jab step *vs.* the crossover step in running a short distance, Edwards and Lind[illegible]rg (8) offer Deck an opposing voice. They reported that the crossover step was [illegible]ficantly faster than the jab (short lead) step at distances of 5, 11, 22 and 37 feet.

Using 16 male college physical education majors as subjects, Slater-Hammel (19) investigated the subject's ability to move quickly from various standing body positions. The positions were:

1. Knees straight with weight distributed over feet
2. Knees straight with weight on balls of feet
3. Knees bent with weight distributed over feet
4. Knees bent with weight on balls of feet

Although the starting reaction times in each weight distribution group tended to be shorter in the knees bent position, these differences were too slight to be considered significant. The starting positions with the weight distributed

over the feet resulted in significantly faster starting reaction times than those positions with the weight placed over the balls of the feet. Slater-Hammel suggests that starting from the balls of the feet requires more time because of the tendency of most subjects to rock back on their heels before starting.

Although the researchers are not unanimous in their conclusions regarding the optimum stance for fastest starts, most of the evidence suggests that the bunch stance with high hip elevation is best. Since other factors such as stability and maneuverability are important to the football stance, appropriate modifications of the suggested starting stance are often indicated.

When starting in a lateral direction, the crossover step is probably best for fast starts. The fact that Deck found no speed advantages in the crossover initial step indicates a need for further study of the use of this movement.

When fast movement is desired from a standing position, the best stance is one in which the knees are bent slightly and the weight is distributed over the feet. Starting on the balls of the feet prior to the movement stimuli offers no advantage because of an athlete's tendency to rock back on his heels before making his initial step.

Starting Signals and Movement

In order for an offensive team to be effective, the players must not only be able to start quickly but have unison movement as well. A team's ability to start quickly is influenced by the type of starting signals used. Although there are many variations of auditory starting signals, they can be classified into two basic types: rhythmic signals — those without cadence, and nonrhythmic signals — those without cadence. Some coaches feel that rhythmic signals are better because they allow players to respond to a mental approximation of the rhythmic time interval instead of the actual go signal, thereby resulting in faster starts. Other coaches feel that nonrhythmic signals are better because they result in greater unison of movement. Other areas of disagreement regarding starting signal presentation are (a) the optimum interval between "digits" or "sounds" for rhythmic signals and (b) the optimum holding time for player in the "set" position.

In 1931 Miles and Graves (15) conducted one of the first studies on starting signals in football. It was designed to a) determine the effects of various rhythmic signals upon speed, uniformity and offsides; b) compare the effects of anticipatory (rhythmic) and nonanticipatory (nonrhythmic) signals; and c) compare the effects of rhythmic and nonrhythmic signals upon speed, uniformity and offsides. Four subjects were used in the study. The rates of rhythmic signals studied were 1.6, 1.5, 1.0 and 0.5 seconds between digits. In the nonrhythm experiment, the routine was to call a series of 5 single-digit numbers with irregular time

between digits. The investigators reported that the fastest movement times resulted from the rhythmic signals. Subjects had more offsides when the signal presentation was 100 single digits per minute for rhythmical cadences and 60 single digits per minute for nonrhythmical cadences. The best holding time was between 2 and 5 seconds, with fewer offsides resulting when the go signal was early in the series of digits.

Thompson (21) and his colleagues studied starting signals and movement times of high school and college football players. Using an electric 1/100 second timer they measured the time it took their subjects to move a distance of 18 inches. The starting signals used were: rhythmic digit signal (one, two, three, four), rhythmic word-digit signal (hut-two, hut-two, hut-two), nonrhythmic word-digit signals and nonrhythmic color signal (red, green, orange, etc.). Rhythmic digit starting signals were found to result in the fastest movement times for both high school and college players.

While studying the effect of variations in hand and foot spacing on movement time and force of change, Owens (17) used both rhythmic and nonrhythmic starting signals. He observed that movement times were significantly faster when subjects were started with rhythmic signals. Of the 3,323 trials measured, 123 (approximately 4 percent) resulted in offsides; of these, 95 (77 percent) occurred when a rhythmic count was used.

Paige (18) studied the effect of the length of time linemen are held at the ready position upon reaction time, movement time and response time (movement time plus reaction time). Twelve linemen from the 1969 Indiana University football team were tested under three holding times (foreperiods) of 2, 4 and 6 seconds. Each foreperiod duration was tested with a preparatory command (preset position) and without a preparatory command (set position). Paige found that although reaction time increased (became slower) as the holding time increased, movement time and response time were not significantly affected by the different holding times. He also found that optimum holding time for quick reaction by the linemen was 2 to 4 seconds. This finding concurs with that of Miles and Graves. Nakamura's (16) conclusion that 1.5 seconds is the optimum time to hold track sprinters between the command "get set" and the gunshot concurs with Owens' finding of 1.5 to 2 seconds.

The preponderance of evidence seems to indicate that rhythmic signals are best if speed of movement is the main concern. Although nonrhythmic signals result in somewhat slower starts than rhythmic signals, they result in fewer offsides than rhythmic signals. If rhythmic signals are used, the optimum rate is 100 single digits per minute, or approximately 0.6 seconds between digits. If nonrhythmic signals are used, the best rate is 60 single digits per minute, or 1.0 seconds between digits. For fastest starts the go signal should be given within 2 to 4 seconds after the players have assumed their "set" positions.

Sprint Running

Mechanical analysis of sprint running reveals that of the factors that determine efficiency, four of the most important are: a) the force of the push by the rear leg, b) the angle of the knee lift, c) the length of the stride and d) the angle of the leg with the ground at touchdown. An understanding of these aspects is vital to the teaching of sprinting. Fenn (10, 11) observed that proficient runners tend to raise the knees high as the free swinging leg is thrust forward. Evidence to support Fenn's conclusion is offered by Bunn (2).

Barlow and Cooper found the following in relation to the fast sprinter in track: "The fastest sprinter displayed shorter reaction times, acquired greater total block time, achieved a longer first stride, and obtained much greater horizontal and vertical components of force while minimizing breaking force during the first stride." (1)

After a six-year track sprint experimental program, Cooper and his associates arrived at the following conclusions, which may have implications for starting quickly in football.

1. When starting, the stronger leg should be placed on the front block. Fifteen untrained sprinters achieved b tter time in a 5-yard sprint by using the stronger leg against the front block.
2. Response time to the starting signal does not appear to be an important factor in the time required to run a given dash distance. There is a great difference between quickness of movement and speed of movement when starting and in sprinting. It is important to use proper running form off the blocks and throughout the race.
3. Removal of the rear block so that the sprinter starts with use of only the front block adversely affects starting speed. (This research was done to test the importance of the rear block in starting.)
4. The optimum time for holding a sprinter at the "set" position is slightly beyond 1½ seconds. The response time to the starting gun is slower when the holding time is longer than 2 seconds.
5. At the time of the program the medium elongated starting stance was found to be best. Now the bunch starting position (mean distance 10.9 inches or slightly longer between the blocks) appears to be the most effective.
6. There appears to be no relationship between the amount of pressure exerted against the blocks and the time recorded in running a specified distance (5 yards in this case). The greatest force exerted against the blocks did not yield the fastest time for the performer.
7. When starting, the average good sprinter's rear leg exerts considerably more force than the front leg on the blocks, but the force from the front leg is applied for a longer time. *It would seem from the findings*

in this study that the runner should attempt to get the rear foot into action against the ground as soon as possible. (3)

Hubbard (13) studied the running habits of 10 subjects — 5 trained and five untrained. After analyzing the action of certain key muscles of the lower limb in relation to the movement of limb oscillation used in walking and running, he concluded that improvement in running results not from taking more steps per second, but from increasing the length of the stride. Fenn suggests that a runner loses some momentum when his foot strides the ground. He points out that a fast runner's lead foot makes contact with the ground almost directly beneath his center of gravity. Slocum and Bowerman (20) concur with Fenn's conclusion and offer an explanation of its correctness. They state that "A simple force diagram will reveal that the farther ahead of the body the foot strikes the ground, the more acute the angle (the leg makes with the ground) and the greater the declaration from ground resistance."

Using 19 varsity athletes from the University of Maryland as subjects, Deshon and Nelson (5) did a cinematographical analysis of sprint running. Their findings support the concept that efficient running is characterized by high knee lift, long running stride and placement of the foot as closely as possible beneath the runner's center of gravity. They cautioned, however, that an efficient runner's high knee action and long running strides may result from the propulsive force of the runner's rear leg rather than from efficiency. The intercorrelation between the mean length of one cycle (two strides) and the mean angle of the leg with the ground at touchdown was found to be statistically significant ($p < .01$). This finding is suprising because it would appear that as a runner lengthened his stride he would decrease the angle between his leg and the ground at the point of contact. Deshon and Nelson explain that the apparent conflict between length of stride and angle of touchdown may also result from the propulsive force of the rear leg. As they point out, these two effects would seem to cancel each other out since lengthening the stride increases speed, but reducing the angle of touchdown tends to decrease speed. Further research is needed in this area.

Dintiman (7) studied 150 male freshmen and sophomores to determine whether a flexibility training program and a weight training program would affect the subjects' running speed when used as supplements to the conventional method of training sprinters. The following experimental groups were organized:

Group A	– Flexibility and sprint training	Control Group I	– Sprint training only
Group B	– Weight training and sprint training	Control Group II	– Inactive
Group C	– Flexibility training, weight training and sprint training		

The subjects trained three times a week for eight weeks. The 50-yard dash from a running start was used as the speed test. Dintiman found that sprint training supplemented by weight training or flexibility training was not significantly better than sprint training alone. But a program that used weight training *and* flexibility training to supplement sprint training was significantly better than a program of sprint training alone.

After reviewing the research in this area, it seems safe to conclude that running speed is determined by length and frequency of stride. To increase speed, one or both of these factors must be increased. Although efficient running is characterized by long strides and high knee lifts, it seems unwise to try to increase a performer's speed by encouraging him to lengthen his stride or raise his knees higher. If the stride is grotesquely stretched there is a good likelihood that the lead foot will make ground contact well in front of the runner's center of gravity, thereby increasing the period of deceleration caused by ground resistance. An efficient runner's long stride is probably the result of the driving forward of his entire body by the force from the rear leg, rather than from the grotesque stretching of his lead leg. The same explanation holds true for the high knee lift.

Placement of the lead foot directly beneath the body's center of gravity is another characteristic of efficient running. Whether this aspect of efficient running is a cause or an effect is uncertain.

Because the force created by the push of the rear leg is one of the most important determinants of efficient running, runners should give this factor careful attention when training. A conventional sprint training program supplemented by weight and flexibility training is probably the best method for football players to increase their sprinting speed.

Starting Speed and Blocking Performance

In a 1952 investigation, Elbel and Wilson (9) studied the relationship between body weight and force of charge, body weight and speed of charge and speed of charge and the amount of force exerted. Using 45 members of the University of Kansas football squad as subjects, they measured the speed of charge through a 36-inch distance and the amount of horizontal force exerted on a dummy located at the end of the charging distance. They found a positive correlation between body weight and force exerted, but no correlation between speed of charge and force. They also found that as weight increased, speed of charge decreased.

Manolis (14) studied the relationship of charging time and blocking performance. The subjects, 31 members of the University of California football team, were tested for average charging time over a 12-inch distance. Ratings of blocking performance were determined from five game movies by three experienced judges

for 13 of the subjects. Manolis reported that no statistical significant correlation existed between blocking performance and speed of charge.

Owens conducted a study to determine "the effect of front-to-rear and lateral variations in foot spacing and variations in hand-to-toe anterior-posterior spacing on the force of shoulder impact at the end of movement through a 36-inch horizontal distance". He found that although the differences in force obtained from 40 different stances were insignificant, differences in movement time due to stance variation were detected. Owens also found that as movement time per stance decreased, force of shoulder impact increased.

Owens' finding regarding force and speed conflicts with that of Elbel and Wilson. At first glance, the latter's conclusion that speed of charge is unrelated to force exerted is quite disturbing. Coaches have always felt that charging speed is a very important determinant of blocking force. Yet, Elbel and Wilson's finding seems to contradict this commonly held belief. An explanation of this apparent contradiction follows.

Force = Mass (Weight) × Acceleration (Rate of Change of Velocity)

An increase in either the mass or acceleration of a player will, by definition, increase his force. Since the rate of a player's motion through the required distance (36 inches in this case) is not the same during all parts of the movement, the times taken by the researchers discussed above represent *average* velocity, not acceleration. Whereas average velocity is of prime consideration in activities where the goal is to cover a distance in the shortest time, only final velocity (velocity at contact of the object) is of consequence to the magnitude of force production. Therefore, Elbel and Wilson's conclusion that force is unrelated to average speed is correct. Force is related only to mass and speed at contact. Although the average speed of the subjects in Elbel and Wilson's study showed substantial variation, evidently their speed at contact was much the same. Owens' detection of a relationship between charging time and the force produced by his subjects indicates that he was able to discern differences in the speed at contact of his subjects. A player can increase his blocking force by increasing either his mass or his acceleration.

Manolis' conclusion that blocking performance is unrelated to charging time must be considered in terms of the methods used in his study. The fact that the blocking performances were taken from film and were not a result of the movement from which the charging times were taken, offers one possible explanation. More study is needed regarding the relationship of charging time to blocking performance.

Weight per se should not be a factor in speed of charging. However, percent of body fat may affect performance (see Chapter 1). Elbel and Wilson give no indication of the body composition of their subjects; therefore, their finding of a negative correlation between weight and speed of charge must be interpreted with reservations.

4. PHYSIOLOGICAL ASPECTS OF FOOTBALL

Because football is an extremely vigorous sport, players must be in optimal physical condition. There are many factors that must be evaluated and planned by the coach if players are to perform their best. Such factors include environmental conditions, nutrition and a medical examination.

Heat Illness

The importance of preventing heat illness in football players cannot be overemphasized. Spickard (7) reported that there are many factors unique to football which make the prevention of heat stroke difficult. Among these are:

1. The environment is often very hot and humid in late summer, particularly in the South, as football practice begins all over the United States.
2. Many players do not exercise during the summer and are not heat acclimated when practice commences.
3. Enthusiastic young players during the first days of strenuous exercise fear to admit they are exhausted and do not report early symptoms of heat illness.
4. Football uniforms are heavy and prevent proper heat elimination.
5. Salt and water loss is great in football players and determination of replacement needs is difficult.
6. Methods of objective measurement of environmental heat, although available, are not in general used by coaches and trainers.

In a comparison of work done in a football uniform and the same work done in a hospital scrub suit (2) it was reported that the sweat loss was 78 percent greater in the football uniform than in the scrub suit. Murphy and Ashe (4) state that acclimation to work in hot environments is probably the

most important factor in preventing heat stroke. Another problem associated with heat illness is whether a player should be allowed to participate after suffering a heat stroke. Murphy (3) reported that the long-term side effects of heat stroke are usually related to liver and kidney dysfunction, and that before a player returns to practice it is essential that he receive a thorough medical checkup. In general, Dr. Murphy's answer would be that:

> A boy who has suffered from heat stroke, and makes a complete recovery, apparently does not harbor any long-term effects. One episode of heat stroke does not appear to make recurrence likely, except that this boy apparently loses a large amount of fluids when exposed to high heat and humidity unlike exercising heavily. Intake of large amounts of water along with salt before and during practice, with the emphasis on the water, is very important.

Since a great deal of information is available concerning heat illness, coaches should make sure that they, their trainers and their players understand its causes and symptoms and employ ways to prevent it. Coaches are also encouraged to abide by the following recommendations:

1. Encourage a preseason conditioning program. (This will not only help keep players fit but will also aid in their acclimation to exercise in a hot environment) (4).
2. Practice should be conducted in the early morning or late evening when the heat index is usually low (7).
3. Use uniforms for practice that are lightweight with no long sleeve jerseys or high socks (4, 7).
4. Provide for adequate rest periods during practice (7).
5. Weigh all players before and after practice. Check all players who lose over 5 pounds per practice. Players who lose over 10 pounds per practice are considered to be in the danger level (3).
6. Provide for the replacement of salt and water (4, 7). Water should be available during all games and practices.
7. Take dry-bulb and wet-bulb temperature readings daily (4). When the wet-bulb temperature is:

   Under 60 degrees F, no precaution is necessary.

   61 - 65 degrees F, alert observation of all squad members, particularly those who lose considerable weight.

   66 - 70 degrees F, insist that salt and water be given on the field.

   71 - 75 degrees F, alter practice schedule to provide rest periods every 30 minutes, in addition to the above precautions.

   76 degrees F and above, postpone practice or have players wear shorts during practice.

For further discussion on heat illness, see Chapter 5.

Nutrition and Diet

Does diet affect performance? What should be served at the training table? Regarding these matters, Van Itallie and his colleagues (9) report that:

> The performance of an athlete can be impaired significantly by a faulty or inadequate diet, even before clinical signs of a deficiency are manifest. But the manipulation of an already adequate diet does not enhance performance. The composition of a meal preceding single-effort events like the high jump has little effect on performance, but performance in tests involving prolonged muscular work is enhanced if carbohydrates stored are replete at the beginning of the test. Obesity is a mechanical handicap in most, though not in all, forms of athletics. The average corporal density of athletes is higher than that assumed for the general population; therefore, the usual height-weight tables give the misleading impression that an athlete of a given height is too heavy and presumably obese. Placing him on a reducing diet would be a mistake. Ordinarily he will spontaneously ingest food in amounts sufficient to maintain his weight. Performance is generally influenced by motivation, skill and other neuromuscular and psychological factors. The training table provides the athlete with the foods on which he has learned to rely; it also provides some of the sense of security generally obtainable by the practice rituals. The best diet for him is a balanced one consisting of a variety of the foods he enjoys in amounts that maintain his weight at an optimum level.

A study was done by Vogeler and Ferguson (10) to determine whether sugar ingestion prior to athletic participation had any consistent effect upon performance. Eight subjects were tested in the 40-yard dash, left and right hand grip and back lift. They performed two sets of each activity each day with a 10-minute rest between sets. Two dextrose tablets weighing 2.4 grams were given to each subject 5 minutes before the first set of each day. The results of the experiment were that the average performance was better with the sugar than without, although the percent of increased performance decreased from the first event to the last, with a sudden drop occurring after the first four events. This might mean that dextrose has an initial positive effect that drops off rapidly.

An experiment by Rose and his associates (6) investigated the effects of a liquid diet. The following is a summary of their report.

> In an effort to obviate vomiting in athletics before important competitive events, a liquid meal was devised and its ingestion was so timed that the stomach would be empty at the beginning of the game. The volume of the liquid meal, served cold at 10:30 a.m., was 474 cc. It supplied 925 large calories; of these 68 percent, 24 percent and 8 percent were contributed respectively by carbohydrate, protein and fat. It passed through the stomach in less than 2 hours. It did not differ from the conventional solid meal with

respect to subsequent hunger, diarrhea or weight changes, but in those who took it dryness of the mouth was less frequent during the game, strength and endurance seemed to be improved and both vomiting and muscular cramps were eliminated.

From the findings it would seem that a normal balanced diet is recommended for best football performance. There is evidence that the carbohydrate storage level can affect performance. Further research is indicated especially in light of the recent influx of "high protein" diets and "energy" foods.

Body Fat

The following is a summary of a study by Thompson (8) in which he recorded the changes in body fat during a football season:

A practical way to study changes in body composition, especially body fat, by the use of skinfolds has been demonstrated. Skinfold measurements — abdomen, chest, arm — were made on varsity football players at the beginning and end of a season. Using this information, changes in body composition that occurred during conditioning and training were studied. Body weight did not change significantly, but significant losses occurred from the three skinfold sites. Body density as estimated from skinfold data increased with training and conditioning. Presumably this increase was due to loss of body fats and increase in muscle mass and other bodily components.

The significance of these findings for the coach involves his attitude toward the condition he desires for players reporting for initial practice sessions. He should consider body composition and not just the weight of the players in order to determine their physical condition. Improvement through the loss of body fat without any significant loss of weight could occur.

Metabolic Level

Baldwin and Shaw (1) did a study on four football players (two starters and two substitutes) to obtain indices of changing metabolic levels that occurred during the football season. Metabolic tests were made using a portable Sanborn graphic apparatus. Records of changing body weight, pulse rate, and systolic blood pressure were kept. Determination of the metabolic rate of each player under the usual post-absorptive and resting conditions were carried out early in the football season and again about two months after the seasons ended. The metabolic levels of each player fell within 10 percent of the Sanborn normal standards. The per minute oxygen consumption of the starters showed a day-by-day increase during periods of preparation for critical games. Such increases

were not evident in the case of the substitute players. As the season progressed, the starters reached higher metabolic levels before each successive game. This data indicates that physiological effects of emotional disturbances are responsible for widely variable metabolic levels in athletes faced with competitive conditions.

Preseason Medical Evaluation

In his report Naughton (5) states that the preseason physical examination is a relatively static process to which many athletes are subjected each year. Its value in eliminating subjects with obvious life-threatening conditions has been established. The preseason evaluation might assume greater importance if physicians and coaches combined the contributions of exercise physiologists and clinicians to develop and administer active evaluation tests to athletes either in the laboratory or on the playing field.

Summary

There are many factors unique to football which make the prevention of heat illness difficult. It can be accomplished, however, through an understanding of its causes and symptoms and through adherence to the recommendations of the medical profession. Although further research is indicated, evidence to date seems to show that the optimum training meal for football players is a normal balanced diet with special attention given to the carbohydrate storage level.

Coaches are advised to consider body composition along with body weight when assessing players' physical condition. Evidence indicates that physiological effects of emotional disturbances are responsible for widely varying metabolic levels in athletes faced with competitive conditions. Core temperature, sweat loss, and peak exercise and end recovery heart rates increase when exercise is done wearing a football uniform. Also the more strenuous the activity, the greater the increase in heart rate and the longer the period required for the heart rate to return to normal. The preseason medical evaluation might become more effective if a cooperative effort between coaches and exercise physiologists and clinicians were undertaken to develop and administer an active evaluation test.

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5. FOOTBALL INJURIES

Football injuries have concerned coaches, physical educators and fans since the beginning of the game. During the early years of football, brutality and injury reached such magnitude that President Theodore Roosevelt threatened to abolish the game. Coaches and physical educators responded to the President's concern by initiating rules and controls that were designed to reduce the chances of injuries. The National Collegiate Athletic Association, the NAIA (National Association of Intercollegiate Athletics) and other athletic governing bodies have developed and enforced rules, equipment specifications and officiating procedures that have contributed greatly to the reduction of football injuries. However, although the number and severity of these injuries appear to be on the decline, football injuries continue to cause concern. Although no nationwide statistics are available on the annual number of football injuries, one estimate (19) is that one in five high school football players is injured seriously enough to receive insurance compensation. The Wisconsin Interscholastic Athletic Association listed football as the leading cause of injury in 1969 (19). In 1968 NFL teams averaged seven major injuries per week; 106 of the players suffered injuries severe enough to miss at least four games (7). Because football injuries will doubtlessly continue as long as football is played, it is the responsibility of the coach to conduct the activity in the manner that will afford maximum safety to the players.

Football Fatalities

In 1931 the American Football Coaches Association began to conduct annual surveys of football fatalities. AFCA was later joined in this effort by the National Federation of State High School Athletic Associations. These surveys have

been the basis for the improved equipment and rule changes that have made football a safer and therefore, more enjoyable activity.

During the past 40 years 764 fatalities have been caused directly by football participation (2). This averages 19.10 deaths annually. Although this figure is higher than anyone would like, the incidence of direct football fatalities is very low when considered on a per 100,000 player exposure basis. The average number of direct football fatalities per 100,000 participants was 1.61 in 1969 (3) and 1.41 in 1971 (2). Most direct football fatalities occur in high school football. Of the 23 fatalities that occurred in 1971, 2 occurred in sandlot, 3 in college and 15 in high school (2). Blyth and Arnold (2) report that approximately 55.25 percent of all direct football fatalities occur to players between 16 to 18 years of age. Regularly scheduled games provide the setting for most direct fatal injuries (47.64 percent) (3), while October is the most dangerous month (36.67 percent) for direct fatalities to occur.

Of all football activities, tackling ranks first as the cause of direct fatalities (31.76 percent), carrying the ball is second (15.62 percent) and blocking fatalities rank third (9.71 percent) (2). Defensive players suffer direct fatalities slightly more than offensive players (36 percent to 24 percent) (2). Injuries to the head and neck account for most fatalities (80 percent), although injury to the spine and abdominal-internal areas also cause great concern.

Many football fatalities can only be indirectly attributed to participation in football. These fatalities are caused by a breakdown of some body system as a result of exertion while participating in football or by complications which are secondary to a nonfatal injury (2). Over the past 40 years there has been an annual average of 9.1 such injuries (2). Heat stroke and heart failure are the major culprits in this category.

Injuries to the Upper Extremity

Although the upper extremity is less liable to injury than the lower extremity (17), injuries to the head and spine have received more study than other parts of the body. In light of the serious brain and spine damage caused by football injuries, this special attention seems justified. One source reports that head injuries are the number two cause of injuries in high school (19). This indicates that the football helmet, with its thick padding and sturdy shell construction, is one of the most important pieces of protective equipment (8). Human cadaver experimental studies indicate that the skull fractures with an expenditure of 400-600 in-lb. of energy (8). For maximum protection, coaches should select helmets that offer optimum deceleration at impact. Blows to the head may injure the head itself or be transmitted to the spine, depending on their force and angle of application (17). A study of the location of head blows resulting in fatal injury revealed that the left and right front sides of the head incurred

the greatest amount (22.08 percent) of injury, blows to the top of the head, resulting in spine injury, ranked second (18.33 percent), internal injuries, third (18.18 percent) and blows to the back of the head ranked fourth (12.34 percent).

Injuries to the neck are especially important because of their serious potential. The most common neck injury in football is the lateral neck sprain, or pinched nerve (5). Chrisman and his associates (5) studied neck injuries at two institutions, Amherst College and the University of Massachusetts, over a five-year period, 1959 to 1963. The predominant group of neck injuries that occurred during this period was of the pinched nerve type. Of the 22 cases observed, 17 occurred in football, 2 in basketball and 1 each in wrestling, track (pitfall) and squash (collision against the wall). The investigators observed that players of average build and flexibility are more prone to lateral sprain than either short, thick-necked or limber, long-necked individuals. They noted that low professional pads offer better neck protection than the higher conventional types.

The helmet with a fixed faceguard that protrudes more than 3½ inches is considered to be hazardous by some investigators (16). Schneider and his associates (16) offer evidence for this premise. Their evidence comes in the form of a case study of a football death caused by sudden hyperextension of the head when the faceguard was hit, causing the sharp firm posterior margin of the helmet to strike the cervical spine resulting in rupture-dislocation and spinal cord destruction. They suggested that the face bar may necessitate the development of a chin strap which would release at a certain determined pressure, thereby reducing the force to the back of the neck.

Shoulder injuries are common in football. Although improved shoulder pads have decreased the number and severity of shoulder injuries, the acromioclavicular and shoulder joints remain a great cause of concern for coaches, athletic trainers and physicians. Slocum (17) found that most injuries to these two joints result from contact with other players (63 percent) and with the ground (30 percent). He lists the types of shoulder injuries in order of frequency as: contusions, acromioclavicular joint injury, muscle strain, sprains and dislocations, fractures of the clavicle and other miscellaneous traumatic conditions. Shoulder contusions are caused by direct blows to the shoulder. Properly sized and adjusted shoulder pads offer adequate protection to all of the shoulder areas except the trapezius and lateral part of the neck. Slocum points out that injury to this area most often results from a defensive player flinching and looking away from his opponent, thereby incurring a direct blow from the oncoming player's hips, thigh, knee or elbow.

Injuries to the acromioclavicular joint usually occur in the form of sprains, sublaxation or dislocation. Most common is a dislocation usually caused by a fall on the point of the shoulder. According to Slocum, anterior dislocation of the shoulder joint often results from a tackle in which the tackler looks away from his opponent and passes him too widely while attempting to grasp

his thighs. Fracture of the clavicle is usually caused by falling on an outstretched hand or on the point of the shoulder.

Injuries to the Lower Extremity

Pelvis and lower extremity injuries are less dangerous than those of the upper extremity, but they occur more frequently. Contusion to the brim of the pelvis, or "hip-pointer" as it is commonly called, is a common pelvic injury. The "hip-pointer" usually results from a direct blow to the iliac crest and nearby musculature. Hematoma formation is usually present. About 70 percent of these injuries result from contact with other players or in pile-up situations (17) and the remaining 30 percent result from contact with the ground or other objects. Although this injury may occur in spite of protective padding, proper use of padded equipment is the best preventive measure for this injury.

Proper fitting thigh pads will decrease the likelihood of contusions of the thigh. This type of injury (charley horse) is more likely to occur if the thigh pads are loose or inadequate (17).

Knee injury is one of the most debilitating injuries in football. This is due to the exposed position of the knees and the fact that knee movements are largely restricted to flexion and extension. Many medical officials consider the knee the most vulnerable target for injury in football (14). For additional information on knee stability, see Morehouse's studies (12, 13). Knee injuries may result from contact, or cutting or pivoting movements. Knee injuries resulting from contact are caused as follows: 63 percent from the side, 28 percent from the front and 9 percent from the rear (17). Although there is some evidence to the contrary (4), most researchers feel that the factor which most knee injuries have in common is that, at the time of the injury, the foot of the injured leg is fixed to the ground in such a way that the force of the blow or movement is absorbed by the knee joint. Hanley (4) reports that the following four factors constituted 77 percent of the knee injuries observed in his study:

1. The foot of the injured extremity being fixed to the ground with long conical cleats
2. The weight borne on this extremity
3. The flexion of the knee
4. The torsional force applied to the knee joint.

Pisani (4) disagrees with Hanley's conclusion and argues that a) the mechanism that produces knee injury is similar to that involved in any other accident, varying only in proportion to the force generated and b) most knee injuries occur when the knee is in a "dry-twig" position while the player is at the bottom of a pile-up.

Most researchers feel that knee injuries occur most when the foot is fixed to the ground in such a way as to prevent its movement. To prevent knee

injuries caused by contact or twisting actions, many researchers have looked to footwear variations for help. Rowe (15) used 1,325 varsity football players from New York State high schools as subjects to study the effects of various footwear on knee and ankle injuries. He used five types of shoes and cleats: a) high shoe regular cleats, b) high shoe, disk heel, regular cleats, c) low shoe, regular heel cleats, d) low shoe, disk heel, regular sole cleats and e) soccer or rubber cleats. Rowe's findings indicate that the soccer style or rubber cleats are the best shoes to use for the prevention of knee injuries.

Support for Rowe's findings is offered by Torg and Quedenfeld (20) who, using high school athletes as subjects, studied knee injuries over a period of three football seasons. They used the conventional shoe with 14 3/8 inch cleats and the soccer type shoe. On the basis of their findings they concluded that the conventional shoe is the major factor responsible for knee injuries. Callahan (4), who conducted a similar study with similar results, reported that "the long conical cleats must go, and now, if we are to eliminate some of the crippling knee injuries suffered by these kids."

Doubtlessly factors other than footwear contribute to the high incidence of knee injury in today's football games. More study is necessary to isolate many of these factors. However, the evidence pointing to the dangers of the conventional shoe with the 3/8 inch cleats (4, 15, 20) seems to be so overwhelming that elimination of the shoe must be considered. As a replacement, the soccer type shoe is recommended.

Heat Illness

Heat illness is a major hazard to football athletes, especially in areas where the temperature and humidity are excessively hot and humid. It is one of the true medical emergencies. Its immediate recognition and subsequent treatment are vital to the chances of recovery of its victim. A mortality rate of 22 percent has been reported for heat stroke when accompanied by coma (18). This illness is one of the major causes of indirect football fatalities. An understanding of the methods of prevention of heat stroke is very important to football coaches and other officials who are responsible for athletes' health and safety.

Spickard (18) reports that the three clinical syndromes of heat illness are heat cramps, heat exhaustion and heat stroke. Heat cramps, the mildest form of heat illness, are caused by an excessive loss of sodium chloride through the sweat glands. They can be prevented by generous replacement of salt in the diet using salt tablets or salt solutions (18). Heat exhaustion, a more severe form of heat illness, characteristically produces pallor, weakness, perspiration, muscle cramps and postural hypotension. Heat stroke, the most severe of the three, produces malfunctioning of the cardiovascular and central nervous systems.

Included in the symptoms may be coma, delirium, convulsions and ataxia. Reducing the body temperature is very important when treating heat stroke. A mortality rate of 10 percent is reported for patients with temperatures less than 106 degrees F as compared to a mortality rate of 21 percent for those whose temperature rises past this level (18).

Although heat stroke usually occurs under circumstances that include excessively strenuous practice sessions, inadequate salt and water replacement or infrequent rest periods, the illness has occurred when precautions against these conditions were taken. To aid in the prevention of heat illness many medical officials (6, 10, 18) offer the following suggestions:

1. At least 7 to 10 days of summer training should be devoted to developing heat acclimatization prior to formal practice.
2. No drills in full uniform should be allowed during the first week of practice.
3. Uniforms for practice should be lightweight. Work performed in a football uniform is 70 percent more strenuous than the same work carried out in a hospital scrub suit (18). Work during hot days should be carried out in T-shirts and shorts, or fishnet jerseys if pads are worn.
4. There should be frequent rest periods and replacement of salt and water during practice on hot days.
5. Players who lose five pounds during a practice session in hot weather or who fail to cool off completely between practices should be considered likely candidates for heat stroke.
6. Schools should require a blood pressure test and urinalysis of all football athletes prior to permitting them to participate in football. It has been established that persons with limited cardiac output do poorly in hot weather as the skin circulation is inadequate for body temperature control (10).

Injuries and Synthetic Turf

The effect of synthetic turf on the incidence and severity of football injuries (especially knee and ankle injuries) has become a controversial issue during the past few football seasons. Initially, coaches, trainers and others interested in the welfare of football players received synthetic turf enthusiastically as the answer to football's knee and ankle injury problem. Judge Roy Hofheinz reported that, of the more than 50 football games played in the Astrodome in 1969, there had not been one serious knee injury. He predicted that every major stadium in the country would be covered by Astro-turf or a similar synthetic surface within the next five years. This early period of enthusiasm over synthetic turf slowly gave way to a period of watchful waiting as players, trainers and

team physicians began to complain of injuries that allegedly resulted from the artificial surface (9). Garrick reported a study in which the injury rate was found to be 50 percent higher on dry synthetic turf than on either wet synthetic turf or on other turf in any condition (11). The National Football League Players' Association felt so strongly about the association of increased injuries with synthetic surfaces that it called for a moratorium on further synthetic turf installation, pending further study of the problem by turf manufacturers and some independent agencies. Research sponsored by manufacturers generally found synthetic turf safer than natural turf. Manufacturer-sponsored findings did little to end the controversy, as they were viewed with skepticism and considered self-serving. As responsible independent groups, such as the National Collegiate Athletic Association, staffed by team trainers and physicians began constructing studies of the problem, some manufacturers discontinued their surveys as they realized these groups were better qualified and equipped to conduct the research.

Although there is still insufficient evidence to determine the effect of artificial surfaces on football injuries, the most valid findings at this time indicate that synthetic turf causes neither more nor less football injuries than natural turf (1). The largest, most comprehensive single season compilation of football injuries undertaken to date is the "1970 Intercollegiate Tackle Football Injury Surveillance Report." The results of this study were reported by the Joint Commission on Competitive Safeguards and Medical Aspects of Sports. According to Dr. Samuel Fuenning, Chairman of the Joint Commission and Director of the Student Health Services at the University of Nebraska, the findings indicate that the well-maintained playing surface, be it natural or synthetic, is not an important factor in football injuries (1).

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